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(19)

(54) IMPROVEMENTS IN OR RELATING TO VACUUM METALLISING OR VACUUM COATING

(71) I, CLAUDE JOHN LANCELOT HUNT, a British subject of Romany, Cooks Lane, Kingstone, in the county of Hereford, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention is concerned with improvements in or relating to vacuum metallising or vacuum coating.

In the conventional process of vacuum metallising or vacuum coating, the work-pieces are disposed in a processing chamber which is exhausted to high vacuum and whilst such high vacuum is maintained, electrically heated filaments vapourise the coating material and the vapour condenses on the work-pieces to form a thin coating of the material. The pressure in the processing chamber is then relieved to atmospheric pressure so that the chamber can be opened to permit removal of the coated work-pieces, and, if required, a fresh loaded work-piece holder is then placed in a chamber and the cycle is recommenced. The work-pieces are normally supported on a work-piece holder which may include a filament assembly and a plurality of supports or jigs on which the work-pieces are suspended or otherwise located. In the cycle of the process the pressure within the processing chamber is firstly reduced by a roughing out operation in which a roughing valve is opened to connect the chamber to a vacuum pump. When a predetermined low pressure is reached the roughing valve is closed and further reduction of the pressure to high vacuum is carried out by opening a baffle valve of an oil diffusion pump. After the coating has been effected, the processing chamber is relieved by closing the baffle valve and opening an air admittance valve. Various other valves, gauges etc. may be embodied in the apparatus to control the various sequences of operations in accordance with the particular design of the apparatus.

[*Price 25p*]

There are two conventional types of apparatus used in vacuum metallising or vacuum coating processes. In one type of apparatus the processing chamber is fixed with a horizontal axis and the work-piece holder is loaded through a front opening door. In the other type of apparatus, the processing chamber has a vertical axis and the chamber is vertically displaceable, whilst the work-piece holder is supported on a base plate to which the chamber is relatively raised or lowered.

Despite substantial differences in the construction of both types of apparatus, the cycle of the process steps is similar and it will be appreciated that the total time for a cycle is mainly dependent on the time taken to exhaust the processing chamber to high vacuum as the loading, unloading, and vapourisation steps are effected quickly.

It is an object of this invention to provide an improvement in a vacuum metallising or vacuum coating process whereby the total cycle time is reduced and to provide a substantial improvement in the operation and construction of vacuum metallising or vacuum coating apparatus.

A further object of this invention is to provide for more efficient use of apparatus, especially the oil diffusion pump, by utilising the pump effectively during the whole of the processing cycle, and to increase the efficiency of the pump by eliminating the conventional requirement of baffle valves associated with the pump.

According to this invention I provide a vacuum metallising or vacuum coating process for coating work-pieces with a coating material by vapourisation of the material at high-vacuum including the steps of:—

reducing the pressure in a processing chamber to a predetermined low pressure;

further reducing the pressure in the processing chamber by connecting the pro-

cessing chamber to a reservoir of substantial capacity which is at a high vacuum and which is being evacuated by pump means;

further reducing the pressure to a predetermined high vacuum as required during vapourisation by evacuating both the processing chamber and the reservoir by the pump means;

isolating the processing chamber from the reservoir before the predetermined high vacuum in the processing chamber is to be relieved;

and continuing the evacuation of the reservoir by the pump means to maintain and improve the high vacuum therein whilst the processing chamber is relieved to atmospheric pressure.

In this invented process the processing chamber is roughed out in the conventional manner until the predetermined low pressure is reached. When the processing chamber is connected to the high vacuum reservoir there is an immediate substantial reduction in the pressure in the processing chamber because equalisation of pressures in the processing chamber and the reservoir occurs. The further reduction in pressure required to achieve the predetermined high vacuum is obtained by the pump means which evacuates both the processing chamber and the reservoir.

In certain respects the high vacuum reservoir may be generally regarded as a booster which very effectively shortens the cycle time for the stage in which the processing chamber is evacuated from the low pressure to the required high vacuum.

In the invented process, the immediate reduction in the pressure in the processing chamber when equalisation of the pressures occurs, results in a high rate of de-gassing. It will be appreciated that the various parts of the apparatus which are exposed to the atmosphere during the processing cycle, such as the work chamber walls, work-pieces and the work-piece holder will have gases entrapped therein. At equalisation of the pressures, the density of gas in the combined volumes of the reservoir and the processing chamber is suddenly reduced and this promotes further de-gassing. In the conventional process these gases are only gradually released as the pressure in the processing chamber is gradually reduced to the predetermined high vacuum. In the invented process no effective pumping time is required to achieve a substantial part of the de-gassing, or to achieve the substantial reduction in the pressure of the processing chamber to the equalisation pressure. Thus the time taken for that stage of the cycle including de-gassing and evacuation of the processing chamber from the low pressure to the predetermined high vacuum by the pump means is considerably less than in the aforementioned conventional process.

Additionally, when the processing chamber is isolated from the reservoir, the pump means continues to do effective work by maintaining the high vacuum in the reservoir, and improving said high vacuum so that the differential between the predetermined low pressure and said high vacuum is increased.

In the aforementioned conventional process, the pump means constituted by one or more oil diffusion pumps is kept running during the processing steps in which no effective work is done by the pump means. However, with this invented process the pump means are utilised more efficiently as throughout the cycle of the process steps the pump means is effectively working by either maintaining and improving the high vacuum in the reservoir, or by exhausting the reservoir and the processing chamber to the predetermined high vacuum. Furthermore, as the equalised pressure is lower than the predetermined low pressure, the oil diffusion pump can also operate more efficiently as their critical backing pressure may be maintained even on equalisation.

According to a further aspect of this invention I provide vacuum metallising or vacuum coating apparatus for coating work-pieces with a coating material by vapourisation of the material at high vacuum, said apparatus comprising a processing chamber, a reservoir and an isolation valve for connecting the processing chamber to the reservoir, the reservoir having a substantial capacity and pump means connected to the reservoir for evacuating the reservoir, the arrangement being such that when the isolation valve is open the processing chamber and the reservoir are evacuated to a predetermined high vacuum by the pump means, and the isolation valve is closed before the processing chamber is relieved to atmospheric pressure whilst high vacuum in the reservoir is maintained and improved by the pump means.

In referring to the reservoir having "a substantial capacity" it is intended that the volume of the reservoir be sufficient to obtain an equalisation pressure substantially lower than the low pressure in the processing chamber when the processing chamber and the reservoir are connected on opening of the isolation valve. It is envisaged that the volume of the reservoir should be more than half the volume of the processing chamber.

Preferably, to promote efficient working of the apparatus said pump means comprises at least one oil diffusion pump connected to a holding rotary pump and the oil diffusion pump or pumps does not include a baffle valve.

Additionally, as the capacity of the reservoir is to be substantial it will be large and thus

it may be inconvenient to have it in the vicinity of the processing chamber where work-pieces are being handled.

Accordingly, the reservoir includes a pressure tank connected to the pump means and ducting connecting the pressure tank to said isolation valve, and the isolation valve is disposed in a section of the ducting remote from the pressure tank and defining an isolation chamber.

This apparatus may be of the kind wherein said processing chamber is fixed, has a substantially horizontal axis and has a closable port through which work-pieces may be loaded or unloaded.

Alternatively, the apparatus may be of the kind wherein the processing chamber has a substantially vertical axis and is arranged for vertical displacement between a lowered position engaging a work table and a raised position whereby work-pieces may be loaded on or unloaded from the work table.

Other features, advantages and details of this invention will be apparent from the preferred embodiment of the apparatus described herein.

In order that this invention is clearly understood, an exemplary embodiment will now be described with reference to the accompanying drawings wherein: —

Figure 1 is a diagrammatic front elevation of vacuum metallising apparatus of the vertical type with the processing chamber lowered and with certain parts being sectioned for clarity;

Figure 2 is a diagrammatic side elevation of the apparatus depicted in Figure 1;

Figure 3 is a diagrammatic front elevation of the apparatus depicted in Figure 1 with the chamber in a raised position;

Figure 4 is a diagrammatic side elevation of Figure 3;

Figures 5, 6 and 7 are schematic perspective views of the apparatus depicting the directions of flow in three different stages of the process cycle.

Certain features of the apparatus now to be described are the subject of another application of Patent numbered 57887/70 (Serial No. 1,321,486).

The apparatus comprises a processing chamber 1 of bell-jar configuration which is arranged to be displaced vertically from the lowered position as depicted in Figures 1 and 2 to a raised position as depicted in Figures 3 and 4. The chamber 1 is raised or lowered by a pneumatic cylinder 2 connected by chains 3 to a guide block 4 attached to a mounting 5 one side of the chamber 1. The chains 3 extend over a jockey wheel 6 mounted on a vertical gantry 7, and the guide block 4 engages with vertical guides extending along one side of the gantry 7.

When the chamber 1 is in the lowered position it is supported on a work table 8, and when the chamber 1 is evacuated it is sealed to the work table by the engagement of a peripheral flange 9 of the chamber with the upper face of the work table 8 which has a complementary sealing face.

The work table 8 is provided with a pair of spaced rails 10 by which a wheeled work-piece holder 11 may be supported and transferred to and from the processing chamber when the chamber is in the raised position.

As is best shown in Figure 1, the work-piece holder 11 comprises a base plate 12 on the underside of which sets of wheels 13 are mounted. An upper plate 14 is supported from the base plate 12 by a number of spacer rods of which one is a conductor rod 15 connected to a centrally disposed filament assembly 16. The filament assembly 16 comprises a pair of conductor rods 17 between which a plurality of filaments 18 are connected and on which the coating material, such as aluminium wire, may be supported. The conductor rods 17 are connected into an electric circuit by means of a pick-up on the base plate 12 and the conductor rod 15, a brush box connection 19 on the upper plate 14 and an earthing connection to the apparatus.

Surrounding the filament assembly 16 is a number of work-holders 20 such as jigs which are suitable for mounting the articles to be coated. In this apparatus, both the filament assembly 16 and the work-holders 20 are adapted to be rotated by means of a driving chain arrangement (not shown) engageable with a drive shaft 21 a gear box 22 coupled to an electric motor 23 mounted underneath the work table 8.

The work table 8 is provided with a central port 24 which is connected by ducting 25 to an air admittance valve 26 and a roughing valve 27 which will be referred to later in more detail.

The front portion of the chamber wall includes an observation porthole 28, and the rear portion is formed with a relatively large port 29 constituting the entrance to a passageway 30 leading to an auxiliary chamber 31.

The lower edge of the auxiliary chamber 31 has a flange 32 which provides a seating for engagement with a complementary seating on a flange 33 on the upper end of one limb 34 of an elbow ducting 35. The end of the other limb 36 of the elbow ducting is connected to a further elbow ducting 37 of similar but opposite crank which is connected to a cylindrical pressure tank 38. Two oil diffusion pumps 39, 40 are connected to the tank 38, one at each end.

As can be seen from Figures 5, 6 and 7, an isolation valve 41 is disposed in the one limb 34 of the elbow ducting 35 which constitutes an isolation chamber. The valve 41 is vertically displaceable by a operating rod 42 connected to a lever 43 arrangement movable

by a pneumatic or hydraulic cylinder 44. The isolation valve 41 is arranged to seat within the isolation chamber when it is closed, and to be vertically displaced into a raised position (see Figure 7) wherein the isolation valve 41 extends into the auxiliary chamber 31 at the end of the passage 30 and at a position so as not to obscure the outlet port of the passage.

It should be noted that the actuation of the isolation valve 41 is arranged for "fail-safe" operation so that the valve automatically closes should there be a failure in the pneumatic, hydraulic and/or electrical system.

The ducting 25 extending from the port 24 in the work table 8 leads to the air admittance valve 26 which is opened or closed in respective parts of the processing cycle. The ducting 25 is also connected to the main rotary pump 45 through the roughing valve 27 which may be opened or closed at appropriate parts of the processing cycle. A further ducting 46 is connected to the main rotary pump 45 and a small holding rotary pump 47, and a backing valve 48 which may be opened or closed in accordance with the processing cycle is mounted in the connecting duct 46. The small holding rotary pump 47 is connected by ducting 49 to both of the oil diffusion pumps 39, 40.

A processing cycle will now be described and for this purpose it is to be assumed that the main rotary pump 45, the small holding rotary pump 47, and the oil diffusion pumps 39, 40 are working. The apparatus including the various valves is in the position depicted in Figures 3, 4, and 5 with the processing chamber 1 raised and the reservoir comprising the pressure tank 38, the isolation chamber 34 and the interconnecting ducting are at high vacuum and are being so maintained.

At this stage of the process, the work table 8 may receive the work-piece holder 11 on which the articles to be coated are mounted with the coating material being suspended on the filaments 17. The drive to the rotatable work-holders and filament assembly is automatically engaged when the work-piece holder is placed in position.

During this stage the air admittance valve 26 is open whilst the roughing valve 27 is closed. Additionally, the isolation valve 41 is closed, it should be noted that atmospheric pressure also acts on the exposed valve body to maintain it closed. The backing valve 48 is open so that the reservoir, comprising the pressure tank 38 and the lower isolation chamber 34, is maintained under high vacuum as evacuation occurs through the two oil diffusion pumps 39, 40 backed by the main rotary pump 45 and also the small rotary holding pump 47. The chamber is then lowered into the position depicted in Figures 1, 2 and 6. At this stage, the air admittance valve 26 is closed and the backing valve 48 is closed. The roughing valve 27 is opened so that air is exhausted from the chamber 1, the passageway 30 and the auxiliary chamber 31 by the main rotary pump 45 connected to the port 24 in the work table 8. During this stage the isolation valve 41 is maintained closed and high vacuum is maintained in the reservoir by means of the oil diffusion pumps backed by small holding rotary pump 47 which is isolated from the main rotary pump 45 by the closed backing valve 48.

When the pressure in the chamber has been reduced to a sufficiently low pressure, namely about 0.5 mm mercury, the roughing valve 27 is closed. The backing valve 48 is opened and then the isolation valve 41 is opened.

As soon as the isolation valve 48 is opened the pressure in the processing chamber 1 is immediately further reduced as the roughing pressure at which the roughing valve 27 is closed is substantially higher than the high vacuum maintained in the reservoir by the oil diffusion pump backed by the small holding pump 47. Evacuation of the connected system now proceeds in accordance with the flow lines indicated in Figure 7 showing air being evacuated from the processing chamber 1 through the passageway 30 into the auxiliary chamber 31 and thus into the isolation chamber 34 and through the pressure tank 38 into the oil diffusion pumps 39, 40 which are connected both to the small rotary holding pump 47 and the main rotary pump 45 which are now interconnected due to the open backing valve 48.

When the required degree of high vacuum is attained in the processing chamber, the electricity is supplied to the filaments and the drive to the work-holders 20 and the filament assembly 16 is commenced to rotate the work-holders and the filament assembly. When the filaments have been sufficiently heated, the coating material is vapourised and condenses on the articles carried by the work-holders. When the filaments have cooled sufficiently, the isolation valve 41 is closed and the air admittance valve 26 is opened. When atmospheric pressure has been reached in the processing chamber and thus the passageway and the connecting chamber, the chamber may be raised and the work holder removed for commencement of a further cycle.

In the alternative type of apparatus to which this invention may be applied, the processing chamber would comprise a cylindrical chamber supported so that its axis was substantially horizontal and having a closable front port through which work-pieces could be loaded. The rear or top of the chamber would be connected through a port to an auxiliary chamber in which an isolation valve mounted in an isolation chamber would be operable. The arrangement and the

process would be substantially the same as that described in the foregoing embodiment except that there would be no separation of the auxiliary chamber and the isolation chamber when the isolation valve was closed as the processing chamber is fixed.

The various sequential operations of the valves may be controlled automatically by a control arrangement which is responsive to pressure obtaining in the various parts of the apparatus, and which can accommodate the required time delays. Such a sequence controller is the subject of my complete specification published under Number 1,268,651.

There are various features of may invention which are of especial importance. It should be noted that during the whole period of a cycle the pressure tank and isolation chamber are not opened to atmosphere, also the oil diffusion pumps are operated continuously and thus it is not necessary to provide any baffle valves for the oil diffusion pumps which inherently reduce efficiency. Furthermore, because the total cycle time is considerably reduced compared with the conventional apparatus and processes, my invention enables larger processing chamber to be used to increase the work holding capacity.

WHAT I CLAIM IS:—

1. A vacuum metallising or vacuum coating process for coating work-pieces with a coating material by vapourisation of the material at high vacuum including the steps of:—

reducing the pressure in a processing chamber to a predetermined low pressure;

further reducing the pressure in the processing chamber by connecting the processing chamber to a reservoir of substantial capacity which is at a high vacuum and which is being evacuated by pump means;

further reducing the pressure to a predetermined high vacuum as required during vapourisation by evacuating both the processing chamber and the reservoir by the pump means;

isolating the processing chamber from the reservoir before the predetermined high vacuum in the processing chamber is to be relieved;

and continuing the evacuation of the reservoir by the pump means to maintain and improve the high vacuum therein whilst the processing chamber is relieved to atmospheric pressure.

2. Vacuum metallising or vacuum coating apparatus for coating work-pieces with a coating material by vapourisation of the material at high vacuum, said apparatus comprising a processing chamber, a reservoir and an isolation valve for connecting the processing chamber to the reservoir, the reservoir having a substantial capacity and pump means connected to the reservoir for evacuating the reservoir, the arrangement being such that when the isolation valve is open the processing chamber and the reservoir are evacuated to a predetermined high vacuum by the pump means, and the isolation valve is closed before the processing chamber is relieved to atmospheric pressure whilst high vacuum in the reservoir is maintained and improved by the pump means.

3. Apparatus according to claim 2 wherein said pump means comprises at least one oil diffusion pump connected to a holding rotary pump and the oil diffusion pump/pumps does/do not include a baffle valve.

4. Apparatus according to claim 3 wherein said pump means further comprises a main rotary pump connected to the processing chamber through a roughing valve and connected to the oil diffusion pump or pumps through a backing valve so that when the roughing valve is closed and the backing valve is opened the main rotary pump and the holding rotary pump act through the oil diffusion pump or pumps to obtain said predetermined high vacuum.

5. Apparatus according to any one of claims 2, 3 or 4 wherein the reservoir includes a pressure tank connected to the pump means and ducting connecting the pressure tank to said isolation valve.

6. Apparatus according to claim 5 wherein the isolation valve is disposed in a section of the ducting remote from the pressure tank and defining an isolation chamber.

7. Apparatus according to any one of claims 2, 3, 4, 5 and 6 wherein the processing chamber includes a communicating auxiliary chamber adjoining an isolation chamber and the isolation valve is reciprocable into and out of said auxiliary chamber respectively on opening and closing movement.

8. Apparatus according to any one of claims 2 to 7, wherein said processing chamber is fixed, has a substantially horizontal axis and has a closable port through which work-pieces may be loaded or unloaded.

9. Apparatus according to any one of claims 2 to 7 wherein the processing chamber has a substantially vertical axis and is arranged for vertical displacement between a lowered position engaging a work table and a raised position whereby work-pieces may be loaded on or unloaded from the work table.

10. Apparatus according to claim 9 wherein the processing chamber includes a port leading to a passageway connecting the processing chamber to an auxiliary chamber, and wherein the isolation valve is mounted in an isolation chamber, the auxiliary chamber and the isolation chamber having complementary sealing faces engageable with each

other when the processing chamber is in the lower position.

11. Apparatus according to claim 10 wherein the isolation valve is operable by a rod extending through the isolation chamber which is connected to actuating means.

12. Apparatus according to claim 11 wherein said actuating means is arranged for "fail-safe" actuation.

13. Apparatus according to any one of claims 9 to 12 wherein said chamber is supported and guided for vertical displacement by a gantry on one side of the chamber and a hydraulic or pneumatic ram connected to the chamber through a flexible connection serves to displace the chamber.

14. Apparatus for vacuum metallising or vacuum coating substantially as hereinbefore described with reference to the accompanying drawings.

15. A vacuum metallising or vacuum coating process substantially as hereinbefore described with reference to the accompanying drawings.

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1321640 COMPLETE SPECIFICATION

6 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

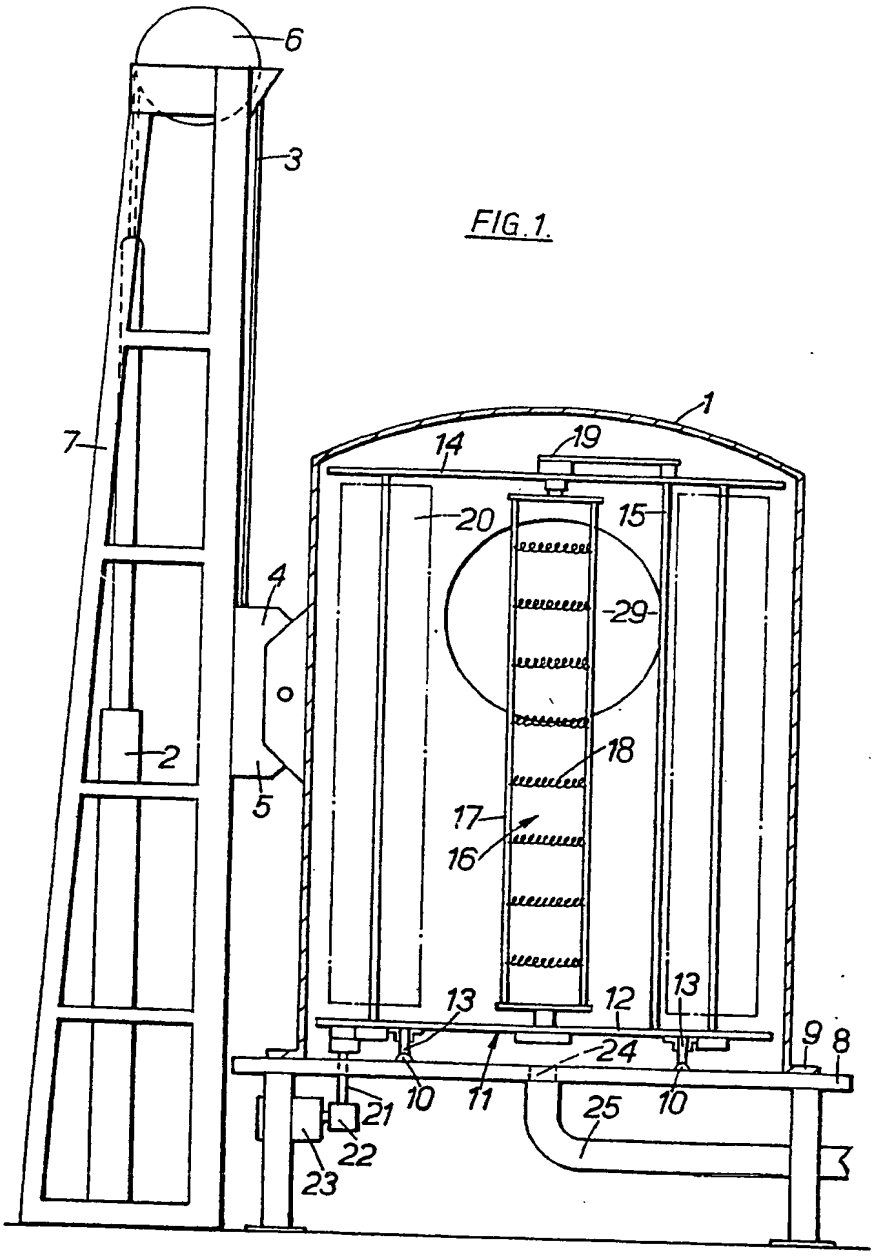


FIG.1.

FIG.2.

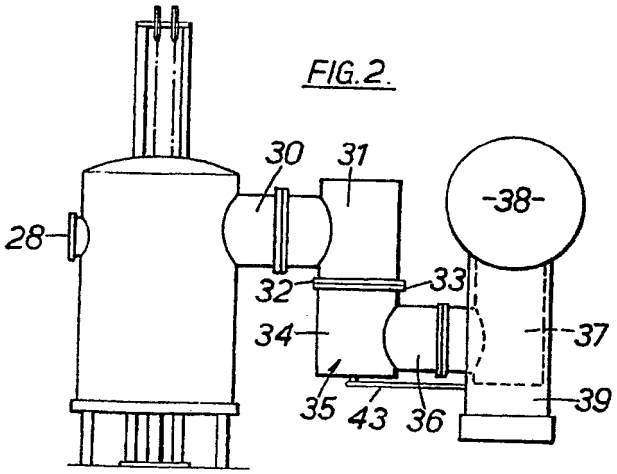
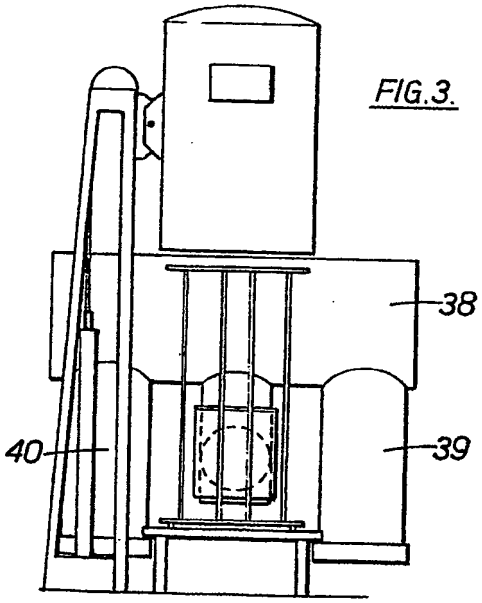


FIG.3.



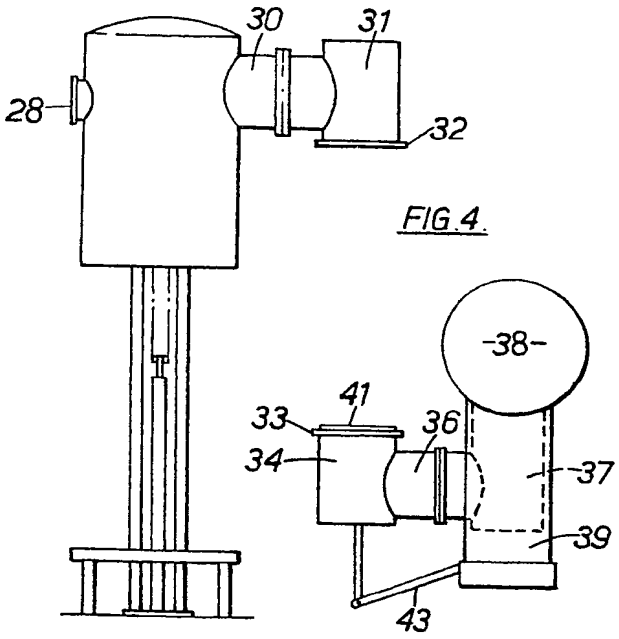


FIG.4.

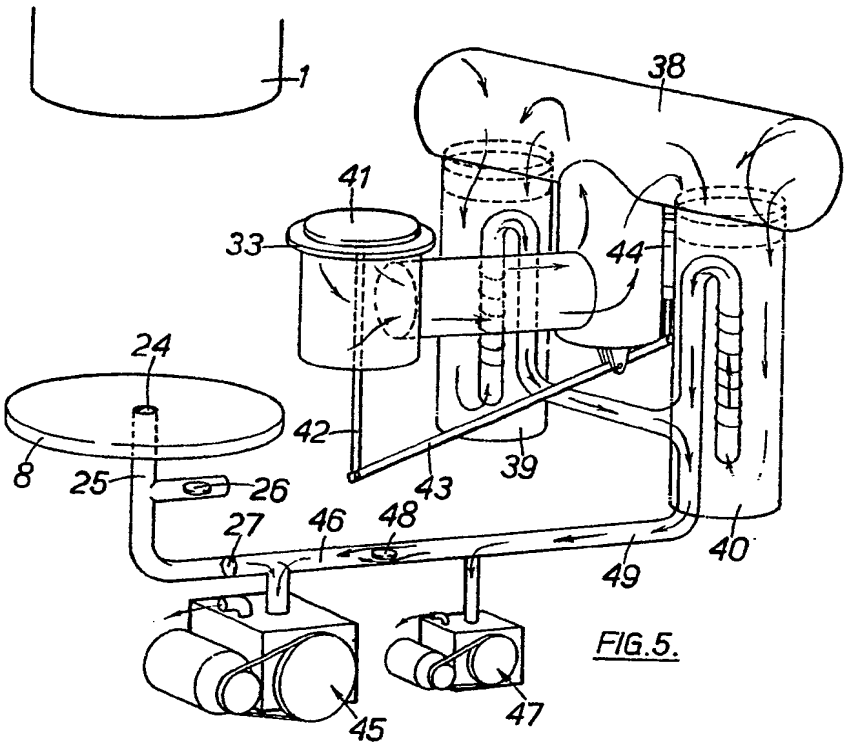


FIG.5.

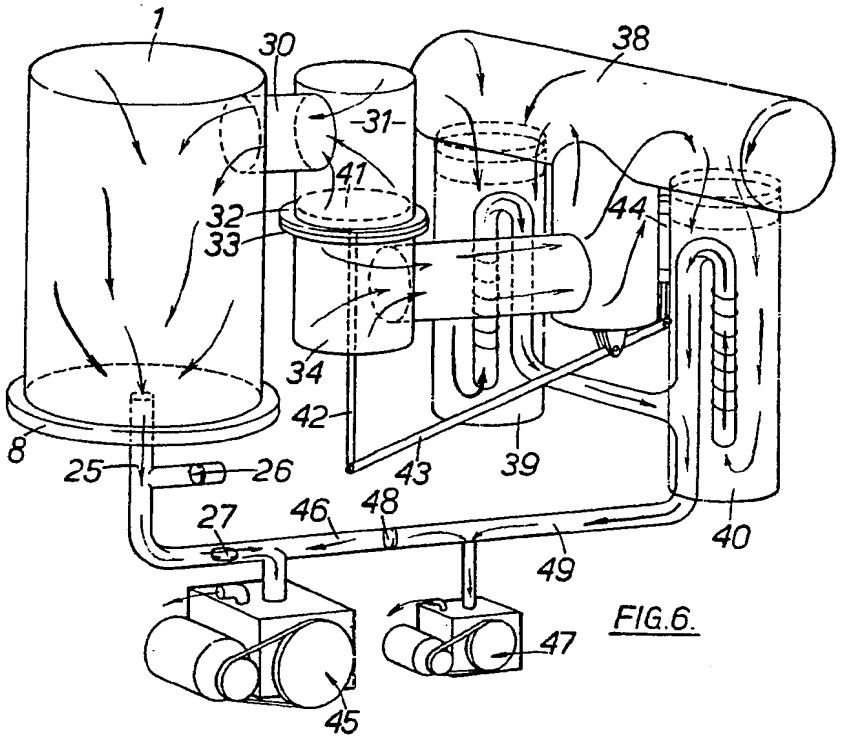


FIG.6.

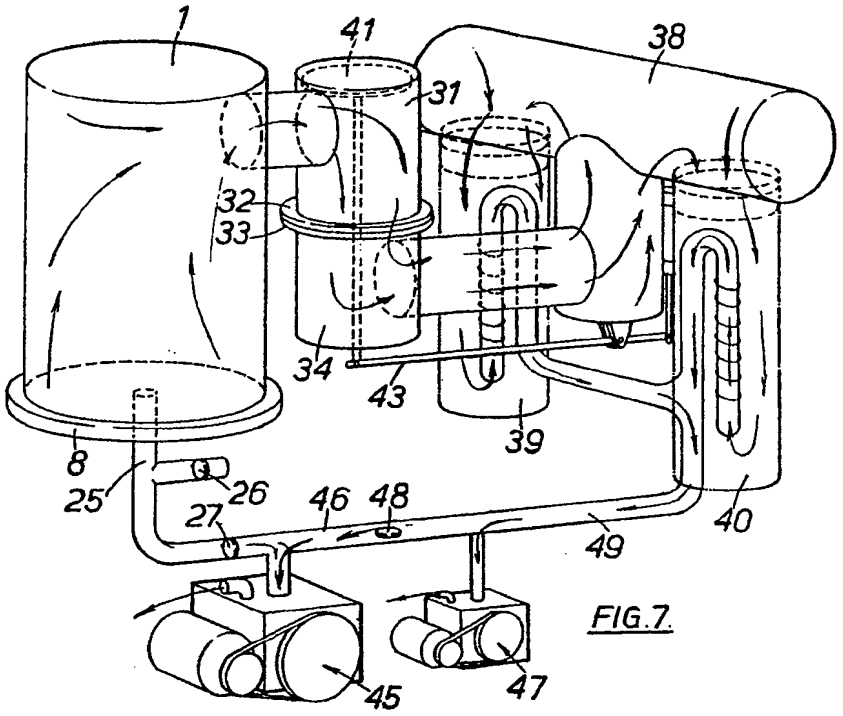


FIG.7.